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Reference: 6065

August 6, 1964

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Picatinny Arsenal
Dover, N. Y.

Attn: Procurement and Production Directorate
SMUPA - PBI

Subject: Contract No. DA-04-200-AMC-477 (A)
Development and Evaluation of a Lightweight Aluminum Honeycomb Case
Monthly Progress Report #6

Gentlemen:

Enclosed is the report describing the work done on the subject contract during the month of June 1964. The report was prepared by the Advanced Structures Group, Research Division, Hexcel Products, Inc., Berkeley 10, California.

Included as attachments are (1) Statement of Man Hours Expended - June 1964, (2) Schedule showing Current Progress - June 1964, and (3) Schedule showing Program of Ensuing Activities - July and August 1964.

Yours very truly,

E. C. Vicars
Research Director

ECV:jem

Attachments (3)

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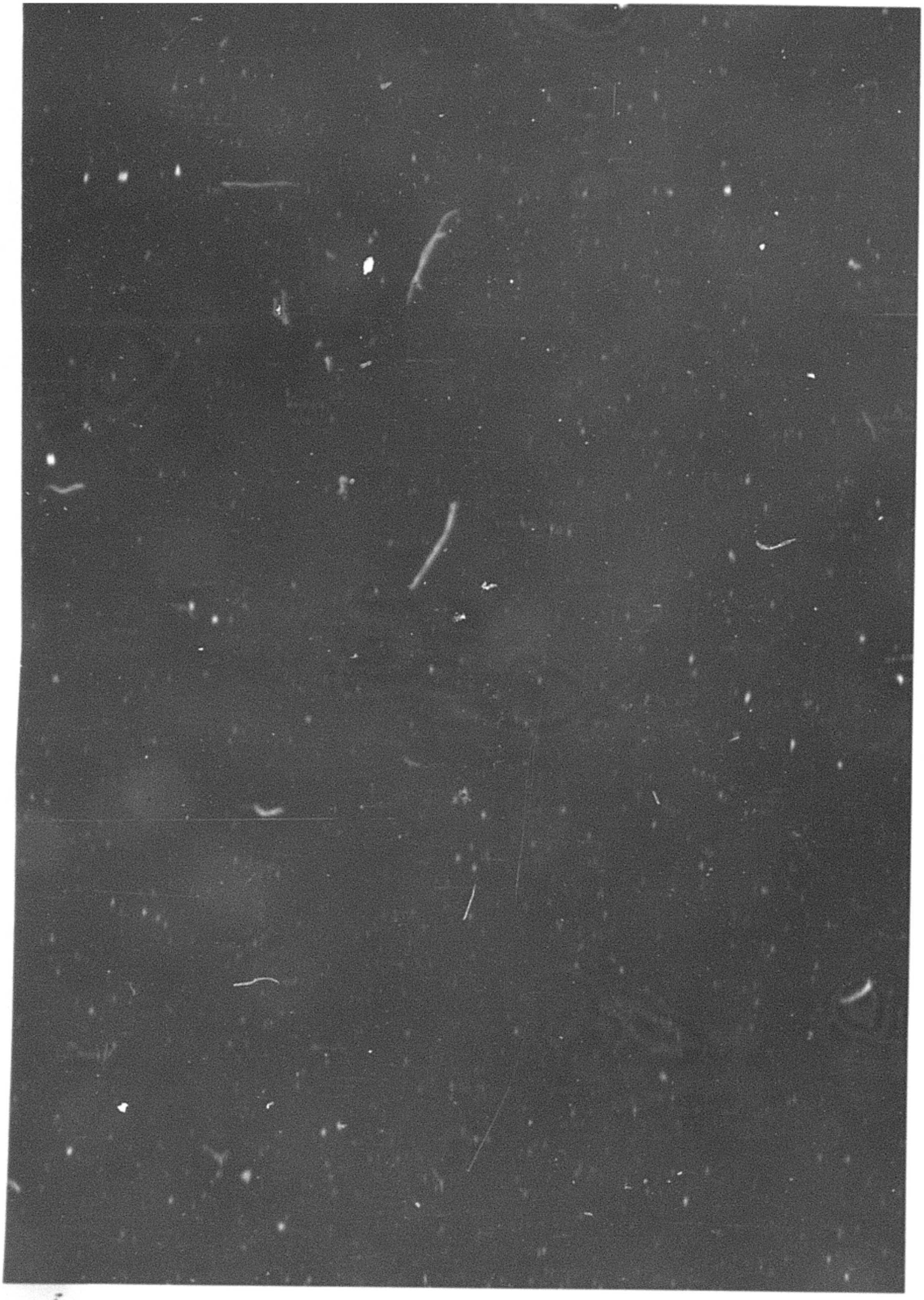


Hexcel Research
Reference: 6065

CONTRACT NO. DA-04-200-AMC-477(A)

REPORT OF PROGRESS
JUNE 1964

1. DESIGN OF CASE HXL-4-477

The design of the case was modified using the results of the evaluation of the testing on Case HXL-3-477 which was given in Progress Report #5. The design changes are summarized below:

1.1 The outer skin of the energy absorption cylinder was changed to .012" hard skin for improved handling characteristics.

1.2 The adhesive used between the outer skin and the core of the energy absorption cylinder did not cover the entire surface (see Figure 2). This allowed the skin to deflect outward freely during the drop tests without contributing the high g level which occurred with the first unit.

1.3 The cavity in the core of the rear end cap was extended through the cap to the outside in order to reduce the rebound action caused by the trapped air during the end drop. (See Figure 1).

1.4 A spare front end cap of 5" thickness was fabricated for the edge drop test.

2. TESTING OF CASE HXL-4-477

2.1 Vibration Tests

A vibration test was conducted in which the Case was placed with the longitudinal axis in a horizontal position and then vibrated along the vertical axis. Peak acceleration values are summarized in Table 1. Severe wrinkling occurred in the skin on the face of the front end cap. The wrinkling was caused by the payload coming loose and rotating, thus twisting the skin.

The Case was then placed with the longitudinal axis in a vertical direction and vibrated along the longitudinal axis. Peak acceleration values are summarized in Table 1. Wrinkles appeared in the skin on the edges of the front and rear end caps when the tie rods connecting the upper and lower support plates were tightened. During the vibration in the 25-58-25 cps range, cracks occurred in the wrinkles.

2.2 Drop Tests

Drop tests were performed after the completion of the vibration testing. A summary of the drop testing is given in Table 2. The drops are listed in the sequence in which they were performed.

2.3 Hydrostatic Pressure Test

After completion of the drop tests, it was discovered that the joint seal between the end plate and the hydrostatic cylinder had been destroyed during the edge drop tests. Thus, the hydrostatic pressure test was not performed.

2.4 Evaluation of Test Results

2.4.1 Vertical Axis Vibration Test - The only vibration of significance was recorded by Accelerometers #2 and #4. These accelerometers were mounted on a part of the dummy payload which acts like a thin web with a weight concentrated at the center. Thus, when the Case is vibrated vertically, the weight vibrates horizontally by oil canning of the thin web. This accounts for the fact that Accelerometer #4 (measuring acceleration longitudinally) recorded much higher g values than Accelerometer #2 (measuring laterally). This is a payload design problem. The Case itself does not appear to have any serious vibration problems.

2.4.2 Longitudinal Axis Vibration Test - The only significant vibration peaks were recorded on Accelerometer #4. The peaks were caused by oil canning of the thin web with a concentrated weight as was discussed above in 2.4.1.

2.4.3 Rear End Drop Test - No rebounding action was observed. A maximum deceleration of 40.8 g's was obtained. This value is very close to the permissible maximum of 40 g's.

2.4.4 Flat Drop Tests - The drops in positions 1 and 2 did not yield enough information because the accelerometers were located perpendicular to the dropping direction.

For the drop in position 3, the first and second peaks recorded by Accelermometer A_1 were under the required value of 27 g's (21.7 and 22.3 g's), but after a duration of approximately 15 milliseconds, a maximum peak of 35 appeared. The same phenomena was recorded by Accelerometer A_2: the first peak was 25.6 g's; after a duration of approximately 12 milliseconds, a maximum peak of 44.5 g's appeared. It is believed that after the two drops in positions 1 and 2, the outer skin was not allowed to bend out as freely as before.

After being dropped in positions 1, 2, and 3, the skin was almost completely restained from bending out freely. Hence, the decelerations which occurred during the drop in position 4 were higher than those recorded for position 3.

2.4.5 Edge Drop Tests - The 5" thick spare cap was used for the edge drop. No damage occurred to the end plate of the hydrostatic cylinder because of this 5" thickness. However, the hydrostatic cylinder near the fixed end was damaged because the case rotated flatwise after the first impact. There was not enough core remaining in the energy absorption cylinder to absorb the second impact since the Case had already been dropped in four positions for the flat drops. Also, the edge drop was conducted twice at the same position on the energy absorption cylinder. This made the damage to the cylinder even worse, though the cap was rotated 180° to a new position. However, the drop showed that the cap thickness of 5 inches is good enough to absorb the energy during edge drop and protect the hydrostatic case from damage.

3. DESIGN OF CASE HXL-5-477

The design of the Case was modified using the results of the evaluation of the testing on Case HXL-4-477 shown in 2.4 of this report. The design changes are summarized below.

3.1 The skin gauge was changed from .0037 to .012 in the following areas: inner and outer faces of front energy absorption cap, outer face of rear energy absorption cap, edges of front and rear caps, and front end of energy absorption cylinder (contact surface between cylinder and energy absorption cap).

3.2 An .012 Alclad 2024-T3 skin was added to the inner face of the rear energy absorption cap (there was no skin on this surface on Case HXL-4-477).

3.3 The 5" thick alternate front cap used on Case HXL-4-477 was not used.

3.4 The overlap of the edge skin of the rear cap onto the end of the energy absorption cylinder in Case HXL-4-477 was eliminated.

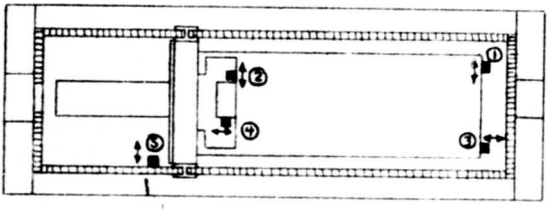
3.5 The circumferential cutouts in the energy absorption cylinder core were extended completely through the energy absorption core. See Figure 4.

TABLE 1

SUMMARY OF VIBRATION TEST RESULTS ON CASE HXL-4-477

FREQUENCY (CPS)	INPUT (g's)	OUTPUT PEAK ACCELERATIONS (g's) *				
		ACCEL. #1	ACCEL. #2	ACCEL. #3	ACCEL. #4	ACCEL. #5
VIBRATION ALONG VERTICAL AXIS						
58	5	10.5	—	—	—	—
122	5	—	—	—	38	—
124	5	—	12	—	—	—
194	5	—	18	9	54	—
VIBRATION ALONG LONGITUDINAL AXIS						
32	5	—	—	—	13	—
42	5	—	—	—	30	—
60	5	—	—	—	25	—
121	5	—	—	—	46	—
125	5	—	12	—	—	—

*Accelerometers were located as shown below. The same instrumentation was used for both tests. The arrows indicate the direction along which each accelerometer measured g values.



SUMMARY OF DROP TESTS ON
CASE HXL-4-477

Case weight = 19.64 lb.
Drop weight = 204.64 lb.
Drop height = 36 inches

See next page for notes.

Type of Drop	Location of Drop	Peak Deceleration (g) & Duration (milliseconds)								Deformation (inches)
		Maximum		2nd highest		3rd highest		4th highest		
		g	t	g	t	g	t	g	t	
End	Rear end cap	40.8(A_3)	5	34.9	5					1.5
Flat	Position 1	20.5(A_1)	10							1.3 (max.)
		10.3(A2)	10							
	Position 2 (180° from position 1)	14.8(A_1)	3							1.3 (max.)
		13.7(A_2)	4							
	Position 3 (90° from position 1)	35 (A_1)	5	22.3(A_1)	5	21.7(A_1)	5			1.2 (max.)
		44.5(A_2)	7	25.6(A_2)	5					
	Position 4 (180° from position 3)	49 (A_1)	4	41 (A_1)	5	37 (A_1)	4			1.3 (max.)
		45 (A_2)	4	41 (A_2)	5	37 (A_2)	4			
Edge	Front end cap 1st Drop	—								4 (max.)
	2nd Drop (Same location on case but cap rotated 180°)	11.5(A_4)								4 (max.)

Notes for Table 2

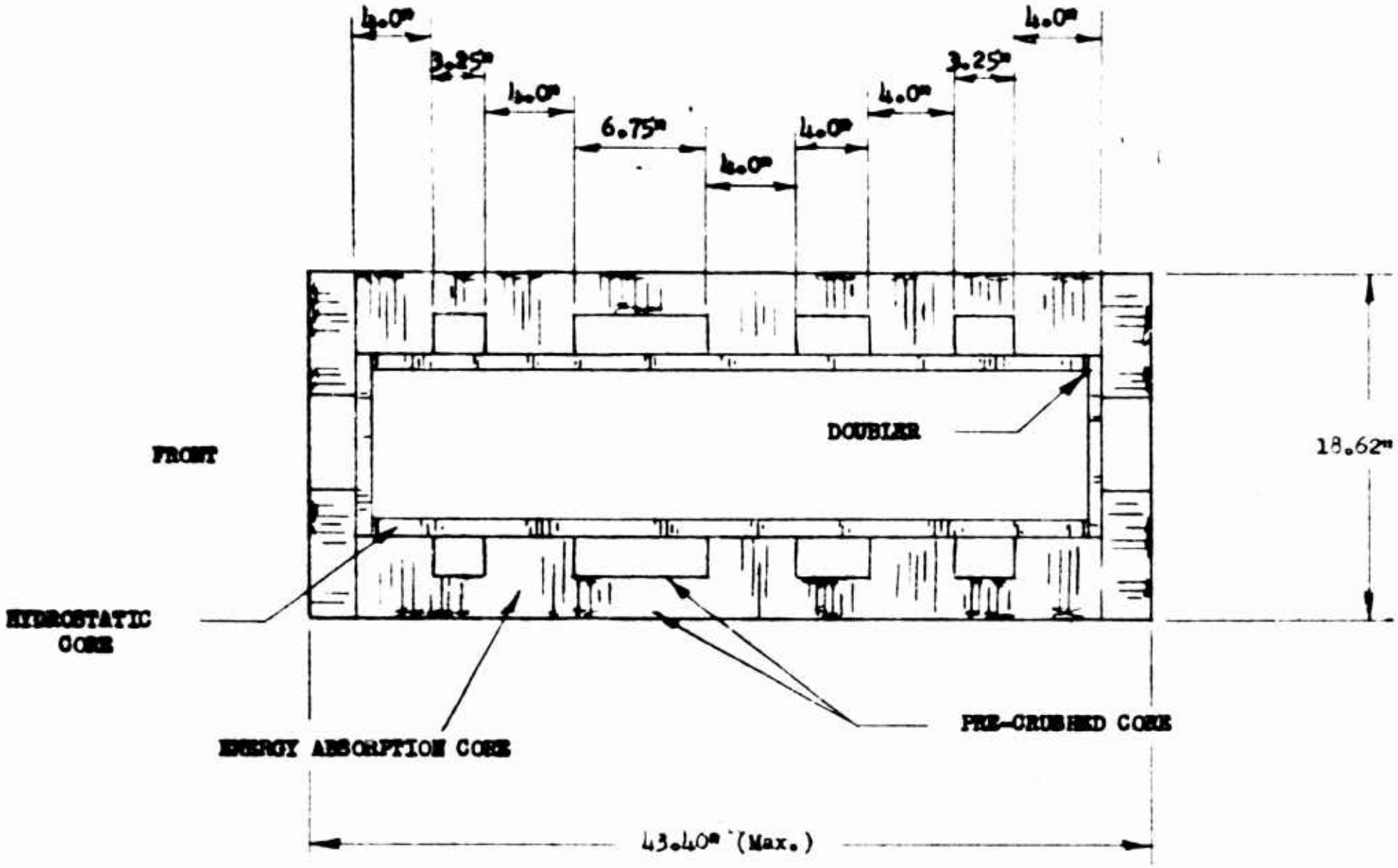
1. See Fig. 2 of Progress Report #4 for explanation of Peak Deceleration and Duration.

2. See Figure 3 for locations of Accelerometers A_1, A_2, A_3, & A_4.

3. Accelerometers A_1 & A_2 were located perpendicular to the dropping direction in positions 1 and 2, but parallel to the dropping direction in positions 3 and 4.

4. Maximum peak (35.0 g's) appeared twice for flat drop position 3.

5. The longitudinal axis of the Case was at an angle of approximately 64° with respect to the ground during the edge drops.



CASE HXL - 4 - 477 ENERGY ABSORPTION CORE FIGURE 1

Not to scale TOTAL WEIGHT: 19.64 lb. 7/13/64 F.P.

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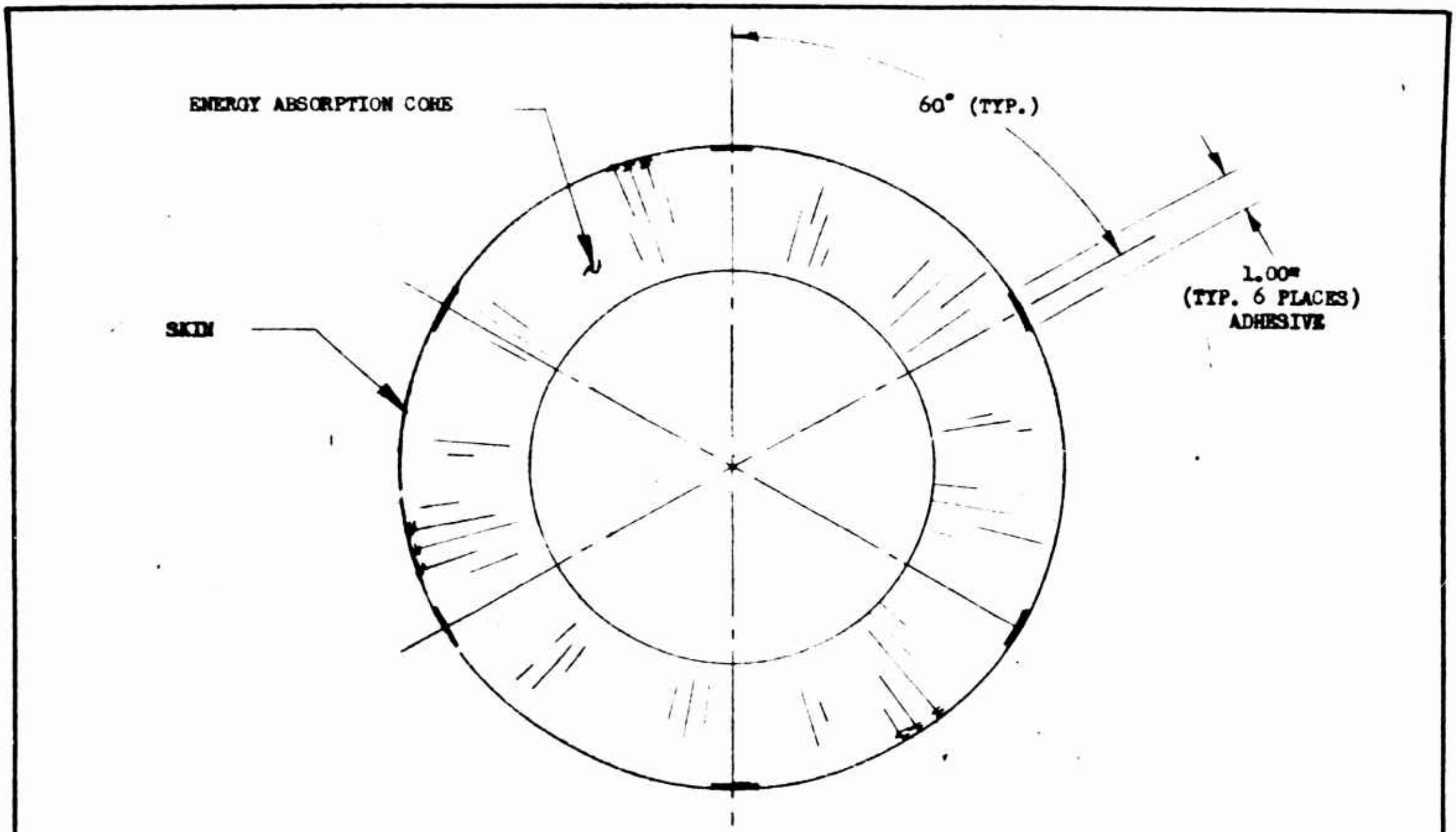

ADHESIVE CONFIGURATION BETWEEN EXTERIOR SKIN AND CORE - CASE HXL - 4 - 477 FIGURE 8

Not to scale 7/13/64 F.P.

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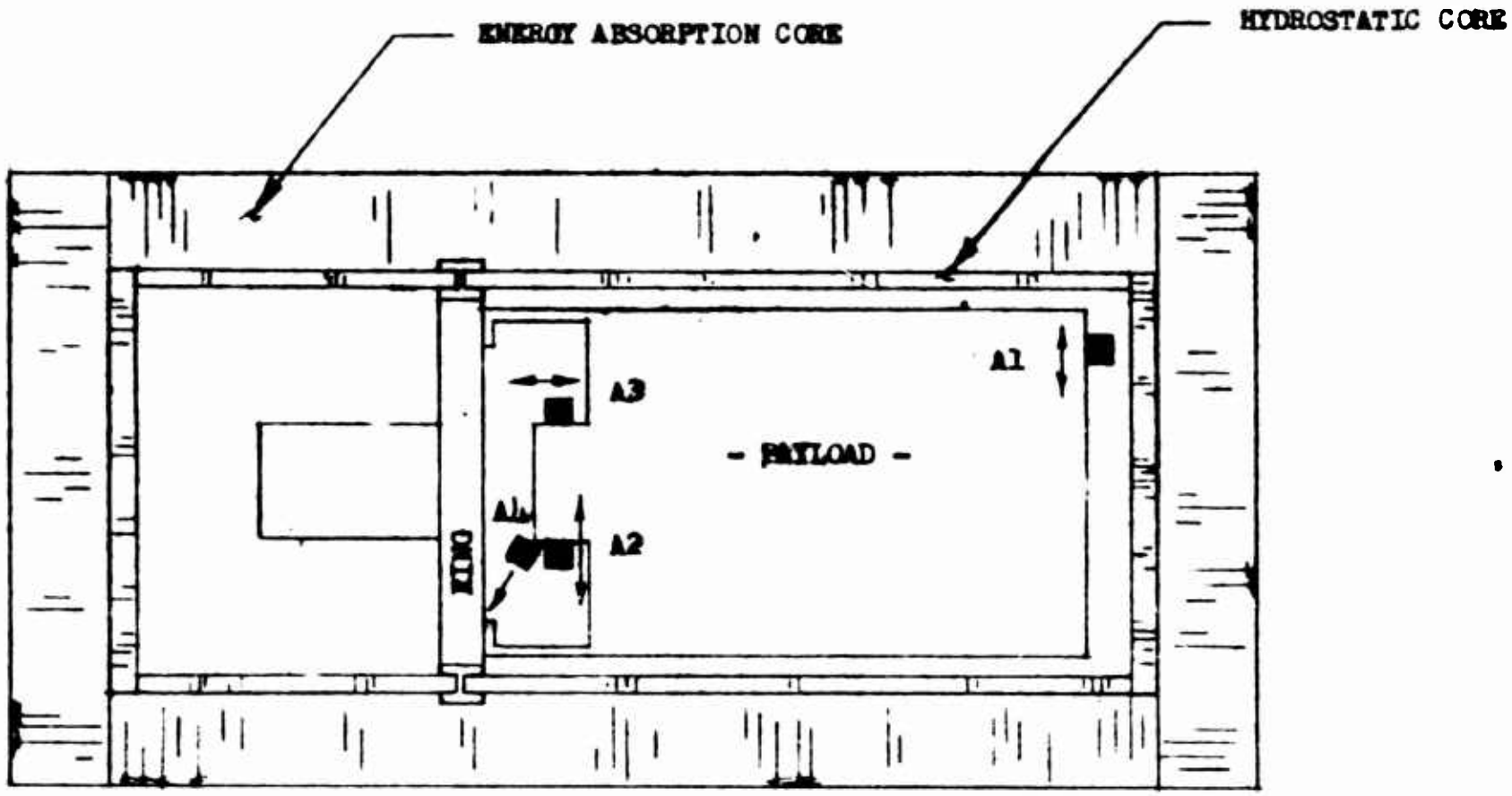
A1 - ACCELEROMETER #1
A2 - ACCELEROMETER #2
A3 - ACCELEROMETER #3
A4 - ACCELEROMETER #4

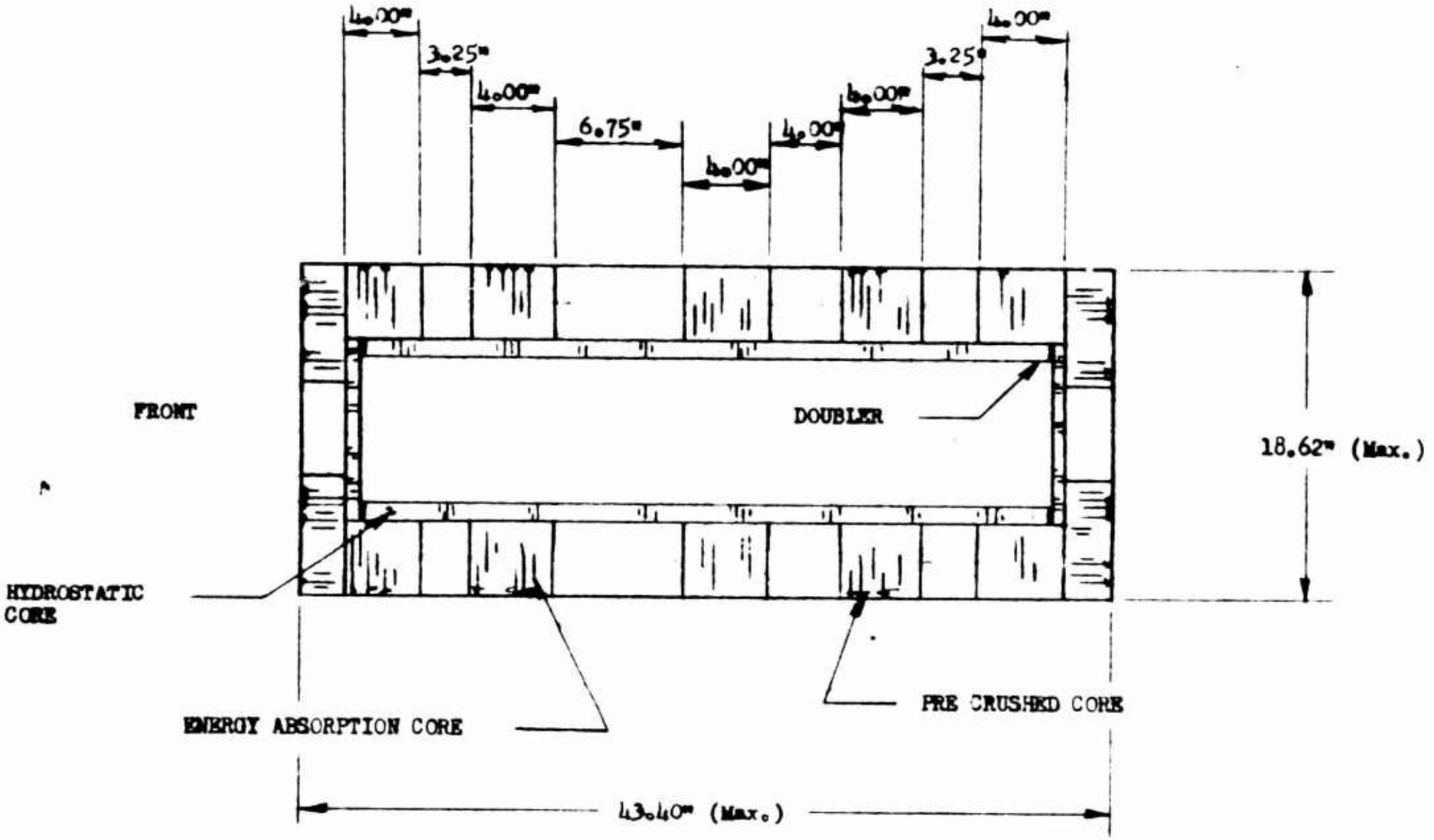


LOCATION OF ACCELEROMETERS FOR DROP TESTS - CASE HXL-4-477

FIGURE 3

Not to scale

7/13/64 F.P.



CASE HXL - 5 - 477 ENERGY ABSORPTION CORE FIGURE 4

Not to scale

7/27/64 F.P.

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CONTRACT NO. DA-04-200-AMC-477(A)

ATTACHMENT #1

STATEMENT OF MAN HOURS EXPENDED - JUNE 1964

	MAN HOURS
Engineering:	
Sr. Professional	4.0
Professional	163.0
Technician:	
Drafting, fabrication, & testing	65.0
Other:	
Clerical	10.5
TOTAL HOURS EXPENDED	242.5

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Reference: [illegible]

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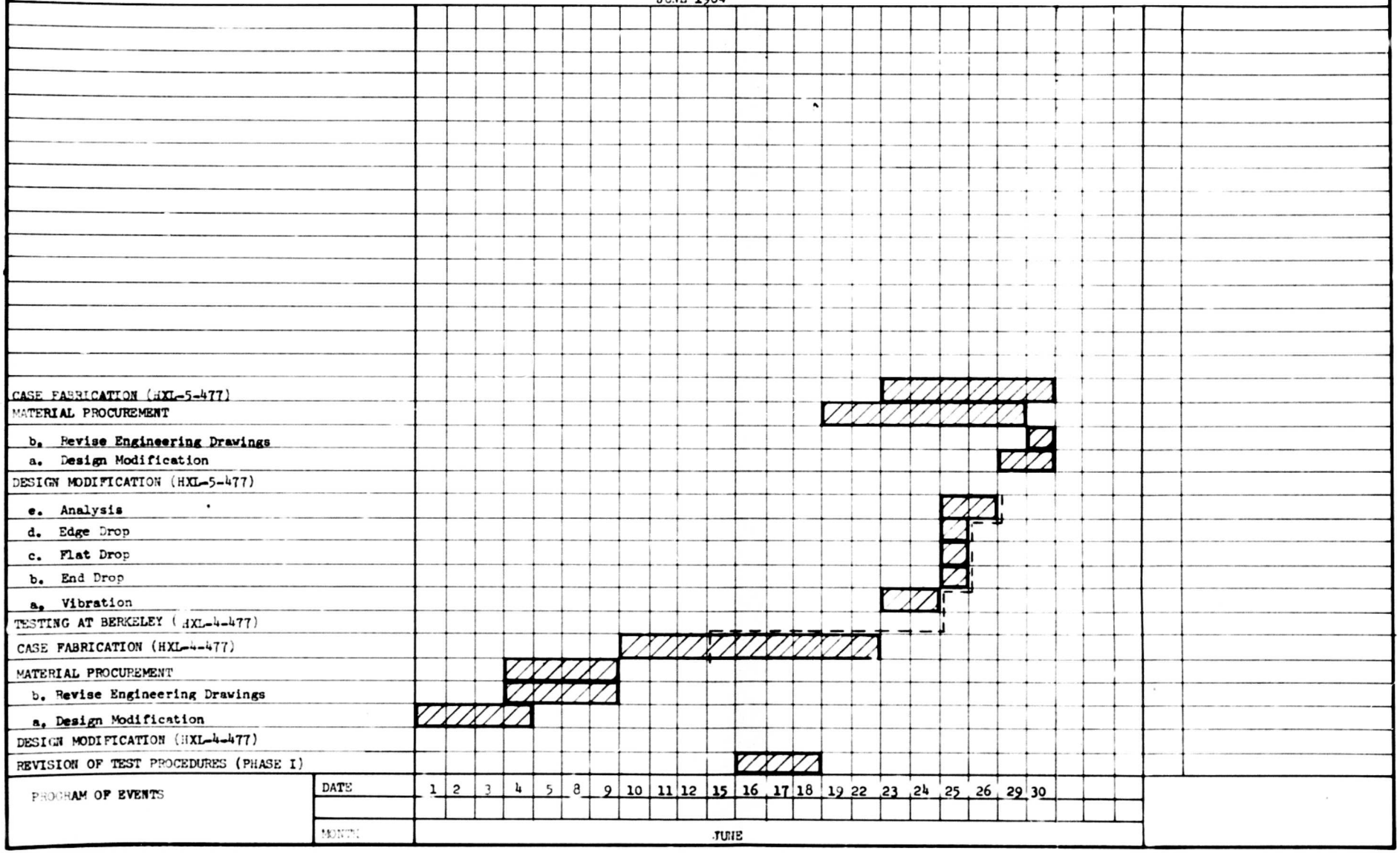
ATTACHMENT #2
CURRENT PROGRESS
JUNE 1964



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PROG

e.	Analysis
d.	Hydrostatic Pressure (22 psi).
c.	Drop Tests
b.	Vibration
a.	Hydrostatic Pressure (12 psi)
TESTING AT BERKELEY (HXL-8-477)	
CASE FABRICATION (HXL-8-477)	
MATERIAL PROCUREMENT	
b.	Revise Engineering Drawings
a.	Design Modification
DESIGN MODIFICATION (HXL-8-477)	
f.	Analysis
e.	Hydrostatic Pressure (22 psi)
d.	Edge Drop
c.	Flat Drop
b.	End Drop
a.	Hydrostatic Pressure (12 psi)
TESTING AT BERKELEY (HXL-7-477)	
e.	Analysis
d.	Hydrostatic Pressure (22 psi)
c.	Flat Drop
b.	End Drop
a.	Hydrostatic Pressure (12 psi)
TESTING AT BERKELEY (HXL-6-477)	
CASE FABRICATION (HXL-6 & -7-477)	
MATERIAL PROCUREMENT	
b.	Revise Engineering Drawings
a.	Design Modification
DESIGN MODIFICATION (HXL-6 & -7-477)	
TESTING AT PICATINNY (HXL-5-477)	
DELIVERY TO PICATINNY (HXL-5-477)	
b.	Analysis
a.	Vibration
TESTING AT BERKELEY (HXL-5-477)	
CASE FABRICATION (HXL-5-477)	

PROGRAM OF EVENTS

A

DATE
MONTHS

JULY 1964: 1 2 3 6 7 8 9 10 13 14 15 16 17 20 21 22 23 24 27 28 29 30 31

AUGUST 1964: 3 4 5 6 7 10 11 12 13 14 17 18 19 20

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ATTACHMENT #3
PROGRAM OF ENSUING ACTIVITIES
JULY AND AUGUST 1964